Lecture 5

Analytical Chemistry

الموضوع

التاريخ / /

Molarity (M) : المولارية

It's the number of moles of solut per Liter of solution.

$$M = \frac{n\ (mole)\ solute}{Volume\ of\ solution(L)} \quad or \quad M = \frac{n\ (mol)\ solute}{V\ (mL)\ solution} \times 1000$$

Unites : M or mol/L or molar or mol/dm^3

$1\ dm^3 = 1\ L$

ملاحظة هامة : اي مركب يكون في صورة (Liquid) بمعنى يكون له حجم يكون عرضة للتغير في درجة الحرارة (Volume) يتأثر بدرجة الحرارة لذا الماء المقطر المستخدم في المعمل يعبر عنا بـ W/W حيث لا يتأثر بالحرارة من التعابير التي تتغير بدرجة الحرارة W/V & V/V & strength & Molarity

example (1) :- A 3.65 g HCl (m.wt = 36.5) was dissolved in sufficient water (H_2O) and then diluted into 2L to prepare HCl solution. Calculate the Molarity of the solution.

mass of HCl = 3.65 g & m.wt = 36.5 g/mol & $V_{solution}$ = 2 L

M = ??

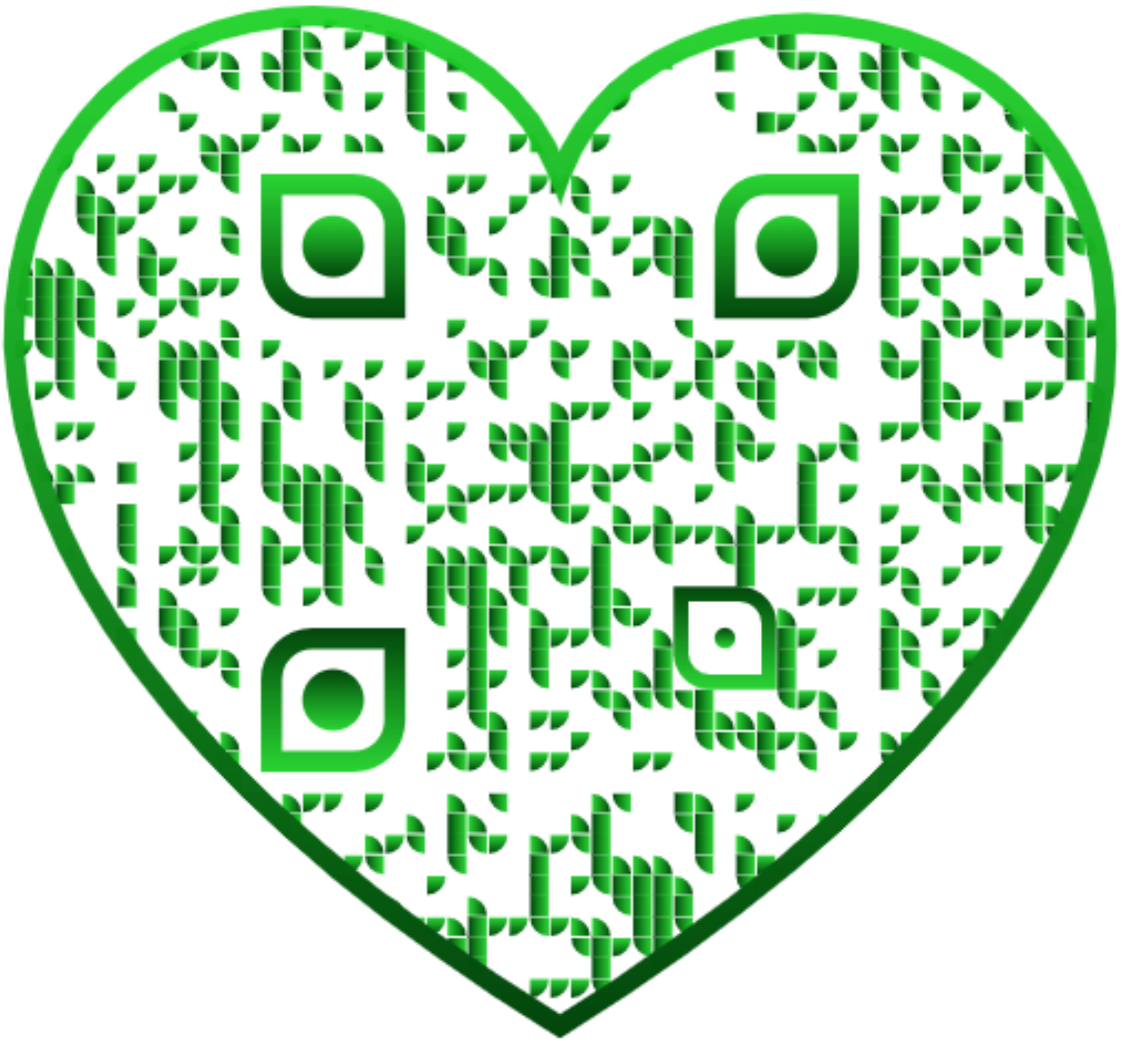
$$\therefore M = \frac{n_{solute}\ (mol)}{Volume\ of\ solution(L)} \Rightarrow n_{HCl} = \frac{m}{m.wt} = \frac{3.65}{36.5}$$

$n = 0.1\ mol$

$$M = \frac{0.1\ mol}{2\ L} = \boxed{0.05\ M}$$

من المثال السابق يعني أن

1 L of HCl solution contains 0.05 moles HCl.



Example (2) :-

If the concentration of Hcl solution is 0.05 M and its density is 1.18 g/ml give percent (W/w)% solution?

M = 0.05 M d = 1.18 g/ml mass = ?? V = 1000 ml

n_{HCl} = 0.05

$\because d = \frac{mass}{V}$ ∴ mass of Hcl solution = d X V

$mass_{Hcl\ solu} = 1.18 \times 1000 =$ **1180 g**

$\therefore W/w\% = \frac{mass\ of\ solut\ Hcl}{mass\ Hcl\ solution} \times 100\%$

$mass\ Hcl = n_{Hcl} \times M.wt \Rightarrow mass\ Hcl = 0.05 \times 36.5$

$\therefore mass\ of\ Hcl =$ **1.825 g**

$\therefore (W/w)\% = \frac{1.825}{1180} \times 100\% =$ **0.15 %**

Example(3) :-

Calculate the (n) of H_2SO_4 and mass of H_2SO_4 in 500ml of 0.324 M H_2SO_4 solution. (H=1 O=16 C=12)

solution. $M.wt = 98\ g/mol$

$n_{H_2SO_4}$ = ?? $mass_{H_2SO_4}$ = ?? $V_{H_2SO_4\ solu}$ = 500ml M = 0.324

(1) $M = \frac{n_{H_2SO_4}}{Volum\ H_2SO_4\ sol} \Rightarrow 0.324 = \frac{n}{500} \times 1000$

$n_{H_2SO_4} = \frac{0.324 \times 500}{1000} \Rightarrow n_{H_2SO_4} =$ **0.162 moles**

(2) $mass_{H_2SO_4} = n_{H_2SO_4} \times M.wt$

$= 0.162 \times 98 =$ **15.88 g**

Example (4) :-

The (m) of $C_{12}H_{22}O_{11}$ = 0.1 m (The d = 1 g/ml
M = ?? M.wt = 342 g/mol
solution

هنا من المهم ايجاد كتلة السكروز وحجم محلول السكروز بالاستعانة بالمعطيات الموجودة.

① ∴ $m = \frac{n_{sucrose\ (mole)}}{1000\ g\ of\ solvent}$ ∴ n = 0.1 of sucrose
mass of H_2O = 1000 g

② ∴ mass = n × M.wt of sucrose.
$mass_{sucrose} = 0.1 \times 342 = \boxed{34.2\ g}$

mass of solution = mass of sucrose + mass of H_2O
" " = 34.2 + 1000 = $\boxed{1034.2\ g}$

③ ∴ $d_{sucrose\ solu} = \frac{m}{V}$

∴ $V_{sucrose\ sol} = \frac{m}{d} = \frac{1034.2\ g}{1\ g/ml} = \boxed{1034.2\ ml}$

④ $M = \frac{n_{sucrose}}{V_{sucrose\ solution}} \times 1000$ ~~M~~

$= \frac{0.1}{1034.2} \times 1000 = \boxed{0.097\ M}$

Normality (N): العيارية

is The number of equivalents weight per one liter of solution.

- $N = \frac{(No.\ eq.\ wt)}{\text{volume of soln (mL)}} \times 1000$ N or eq/L.

- $No.\ eq.\ wt = \frac{\text{mass of solute (g)}}{eq.\ wt}$

- $eq.\ wt = \frac{M.\ wt\ (g/mol)}{X}$ X = units of reacting.

- كلما العوامل ↑ مهم في أنجاز النورمالية.
- النورمالية تتأثر بدرجة الحرارة ايضاً لان حجم السوائل يتغير بتغير درجة الحرارة.
- Normality كمية متغيرة لانها تعتمد على e.g.wt وهو يختلف من مركب الى آخر.

Equivalent weight (Eq.wt) حساب الوزن المكافئ

1- Acid-base reaction

no of H^+ , no of OH^-

- $H_2SO_4 = 2H^+ + SO_4^{2-}$ X = 2

$eq.wt = \frac{M.wt}{X} = \frac{98.1}{2} = 49.05$ (eq)

- $Ba(OH)_2 \rightarrow Ba^{+2} + 2OH$ X = 2

$eq.wt = \frac{M.wt}{X} = \frac{114}{2} = 57$ e.g

- $CH_3COOH \rightleftharpoons H^+ + CH_3COO$ X = 1

$eq.wt = \frac{M.wt}{X} = \frac{60}{1} = 60$ e.g

2- Redox :-

X = no of electrons excepted or donated.
عدد الالكترونات المكتسبة (-) او المفقودة (+)

$H_2C_2O_4 \longrightarrow 2CO_2 + 2H^+ + 2e^-$ $\quad X = 2$

$eq.wt = \frac{M.wt}{2}$

$A_nB_m \longrightarrow nA^{m+} + mB^{n-}$ ← كما عدة عامة للتأيين

A عدد ذرات B
B عدد ذرات A

* الوزن الذري لايجاد الايون (+1-) واتما للعنصر كما هو في الجدول الدوري

$Mn^{7+} + 5e \longrightarrow Mn^{2+}$ $\quad X = 5$

3- In salts :- The Charge positive ion X no of its Atom

ملاحظة مهمة تابعة لشحنة الموجبة
~~X=~~ X = n × ion charge
القاعدة السابقة للتأيين تطبق على الايونات
للايون الموجب $X = n \times (+m)$

$CaCl_2 \longrightarrow 1Ca^{2+} + 2Cl^-$ $\quad X = 1 \times 2 = 2$

$e.q.wt = \frac{M.wt}{X} = \frac{M.wt}{2}$

$Na_2(CO_3) \longrightarrow 2Na^{+1} + 1CO_3^{-2}$ $\quad X = 1$

ions
- Mono atomic: Na^+, Cl^-, Br^-, H^+
- Poly atomic: $OH^-, CO_3^{2-}, NO_3^{-1}, NO_2^{-1}, SO_3^{2-}, SO_4^{2-}$

eq.wt = ?? $Na_2(SO_4)$. M.wt = 142 g/mol

$X = 2 \times 1 = 2$ $\quad e.q.wt = \frac{142}{X} = \frac{142}{2} = 71$ eq

Example (1):-

What is the normality of Na_2CO_3 solution if 1.06 g of $Na_2(CO_3)$ were dissolved in sufficient H_2O and then diluted to 100 mL.

solution

$$N = \frac{\text{no. eq-wt}}{\text{Volume soln (mL)}} \times 1000 \; N$$

$$\text{eq-wt} = \frac{\text{M.wt}}{X} = \frac{106}{2} = 53 \text{ (eq)}$$

$$\text{no. eq-wt} = \frac{\text{mass of solute}}{\text{eq-wt}} = \frac{1.06}{53} = \boxed{0.02 \text{ eq}}$$

$$\therefore N = \frac{0.02}{100} \times 1000 = \boxed{0.2 \; N}$$

Example (2):-

solution consist of 34% of NaOH that has a density of 0.98 g/mL. Calculate:- M, m, X, N

solution:-

$$34\% \; NaOH = \frac{34 \text{ g NaOH}}{100 \text{ g solution}}$$

mass NaOH = 34g [mass

mass solution = 100 g ∴ mass solvent (H_2O) = 100 − 34 = 66 g

$$n_{NaOH} = \frac{\text{mass}}{\text{M.wt}} = \frac{34}{40} = \boxed{0.85 \text{ mole}}$$

~~$V_{NaOH} = \frac{\text{mass}}{d} = \frac{34}{0.98} = 34.7$ mL~~

$$n_{H_2O} = \frac{66}{18} = \boxed{3.7 \text{ moles}} \quad nt = 3.7 + 0.85 = \boxed{4.55 \text{ mol}}$$

$$V_{solution} = \frac{\text{mass}}{d} = \frac{100}{0.98} = \boxed{102 \text{ mL}}$$

$$M = \frac{n_{NaOH}}{V_{sol}} \times 1000 = \frac{0.85}{102} \times 1000 = \boxed{8.33 \; M}$$

~~H2SO4~~

2- $m = \frac{n_{NaOH}}{\text{mass of } H_2O} \times 1000 = \frac{0.85}{66} \times 1000 = \boxed{12.89\,m}$

3- $X_{NaOH} = \frac{n_{NaOH}}{n_t} = \frac{0.85}{11.55} = \boxed{0.19}$

$X_{H_2O} = 1 - 0.19 = \boxed{0.81}$

4- $M = \frac{\text{no. eq-wt}}{\text{Volum soln}} \times 1000$

$\text{eq-wt} = \frac{\text{M.wt}}{X} = \frac{40}{1} = 40\ \text{e.q.}$

$\text{no. eq-wt} = \frac{\text{mass of NaOH}}{\text{eq. wt}} = \frac{34\ g}{40\ \text{eq.}} = 0.85\ g\,\text{e-q}$

$M = \frac{0.85}{102} \times 1000 = \boxed{8.33\,M}$

العلاقة بين التعبير عن التركيز

1- Relationship between precent by mass and Molarity.

$$\text{Molarity} = \frac{(w/w)\% \times d\ (g/ml) \times 1000}{\text{M.wt}\ (g/mol)}$$

Example:

The percent of H_2SO_4 solution is 96.4%(w/w) $d = 1.84\ g/ml$ what is the Molarity?

$M = \frac{(w/w)\% \times d \times 1000}{\text{M.wt}} \rightarrow \text{solution} \quad \frac{0.964 \times 1.84 \times 1000}{98.1} = \boxed{18.1\,M}$

ملاحظة: اذا عطينا (w/w) على 100 نقسم 1000 X
واذا عطينا X 10 نضعها كما هي او اذا لم نعطي

في المثال كانت ~~96.4%(w/w)~~ عطينا 96.4 X 1000 يكون ~~0.964 w/w~~

حل مسألة exercise 22

What is the mass of Na_2CO_3 that's required to prepare 500ml of 0.01 M Na_2CO_3 solution.

$$M = \frac{n_{Na_2CO_3}}{\text{volum soln}} \times 1000 \Rightarrow 0.01 = \frac{n_{Na_2CO_3}}{500} \times 1000$$

(solution)

$$\Rightarrow n_{Na_2CO_3} = \frac{0.01 \times 500}{1000} = \boxed{0.005 \text{ moles}}$$

$$mass_{Na_2CO_3} = n_{Na_2CO_3} \times MWt \qquad M.Wt = 106 \text{ g/mol}$$

$$\Rightarrow mass_{Na_2CO_3} = 0.005 \times 106 = \boxed{0.53 \text{ g}}$$